NBSIR 82-2592 (R)

1982 Annual Report
Office of Measurement Services

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Measurement Laboratory
Washington, DC 20234

October 1982

Final Issued December 1982

Prepared for

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, DC 20234

NBSIR 82-2592

1982 Annual Report

Office of Measurement Services

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Measurement Laboratory
Washington, DC 20234

Office of Measurement Services

Brian C. Belanger

National Measurement Laboratory

John D. Hoffman

Table of Contents

Office of Measurement Services

Programmatic Activities

1. INTRODUCTION

1.1 Mission

The Office of Measurement Services plays an important role as a coordinator and catalyst within NBS and to a considerable extent within the broader measurement community for resolving issues involving traceability and measurement accuracy. OMS provides leadership to industry, scientific and technical institutions, and to other Federal agencies with respect to improving their measurement programs. OMS coordinates measurement traceability services for dimensional, electrical, electromagnetic, radiometric, thermodynamic, and other measurements.

In discharging these responsibilities, OMS must be fully cognizant of new trends in measurement science such as the proliferation of complex automated test equipment (ATE), requirements for dynamic rather than static measurements, requirements for new types of measurements (e.g., optical fiber characteristics), the increasing use of microprocessors in "smart" instruments, and new approaches to measurement standards (e.g., Josephson junction voltage standards). Trends such as these are likely to lead in the long run to restructuring of the way in which NBS disseminates measurement services. By serving on committees, participating in technical conferences, and arranging workshops, etc., the OMS staff maintains a high level of awareness of the direction in which the measurement community is heading and uses this information effectively in working with NBS line management to insure that NBS's services are responsive to the changing needs of the measurement community.

OMS's permanent full-time staff consists of two professional staff, two secretarial and clerical staff and a computer programmer/technician.

1.2 Functions

The principal responsibilities of OMS are:

- To provide generic administrative services for the NBS calibration program;
- To manage a program for the development of new Measurement Assurance Program services (MAP's);
- To provide a central point of contact within NBS for resolving calibration issues;
- To develop policies and procedures for NBS Measurement Services;

- To disseminate information on NBS policy on subjects such as traceability, calibrations, and MAP's;

- To provide the secretariat for the Calibration Advisory Group (see Section 2 for discussion);

- To serve as the NBS focal point for key outside organizations concerned with the above issues, such as the National Conference of Standards Laboratories (NCSL), and the Joint Technical Coordinating Group on Metrology and Calibration of the Department of Defense.

An important part of OMS's function is to increase awareness within the technical community of NBS's programs and philosophy in the calibration and measurement assurance areas. In particular, it is felt that the MAP philosophy can be important to a variety of standards writing groups concerned with measurement quality control. Accordingly, OMS places a high priority on disseminating information on the MAP approach to measurement quality by participating actively in standards committees and other groups concerned with measurement quality.

1.3 Interactions

The principal internal interactions between OMS and NBS technical activities involve the Center for Absolute Physical Quantities (CAPQ), the Center for Electronics and Electrical Engineering (CEEE), the Center for Manufacturing Engineering (CME), the Center for Applied Mathematics (CAM), and the Center for Radiation Research (CRR). Joint activities with these centers are described in the sections which follow.

OMS's contacts outside NBS are wide-ranging. The National Conference of Standards Laboratories (NCSL) is the organization that best represents NBS's customers, hence OMS maintains close liaison with the NCSL Board of Directors and with the NCSL membership. The Department of Defense is the largest single user of NBS measurement services. Accordingly, OMS maintains close ties with the DOD calibration community through the Calibration Coordination Group (CCG) and its subgroups. OMS also interacts with the higher level DOD group, the Joint Technical Coordinating Group on Metrology and Calibration (JTCG-METCAL) of the Joint Logistics Commanders.

2.0 NBS CALIBRATION PROGRAM

2.1 Calibration Workload Summary - Five Years Ending FY 82

Total Activity and Income

	78	79	80	81	82
Total Dollars (in millions)	1.8	2.1	2.3	2.5	3.1
No. of Calibration Folders	2583	2869	2680	3066	3197
No. of Items Calibrated	6,191	6924	6887	7506	6828

Percentage of Calibrations Done For Government Agencies

	78	79	80	81	82
Boulder	39	43	34	29	44
Washington	17	18	17	12	14
NBS	22	23	21	16	20

Services were performed for a total of 1106 organizations in FY 82. Of these 23 were foreign organizations; 75 were federal government; 30 were state and local government; and 96 were universities or hospitals.

Calibration Workload Summary by Division
(in dollars)

	FY 79	FY 80	FY 81	FY82
Electrical Measurements and Standards Division				
Government	63,232	42,072	49,438	71,982
Private Sector	311,262	310,425	340,891	377,373
Total	374,494	352,497	390,329	449,355
Temperature and Pressure Measurement Standards Division				
Government	15,033	25,620	34,349	29,731
Private Sector	152,865	177,808	229,956	261,060
Total	167,898	203,428	264,305	290,791
Time and Frequency Division				
Government	-----	-----	-----	-----
Private Sector	1,500	2,170	2,000	1,416
Total	1,500	2,170	2,000	1,416

	FY 79	FY 80	FY 81	FY82
Atomic and Plasma Radiation				
Government	-----	-----	-----	-----
Private Sector	4,500	1,300	5,620	30,412
Total	4,500	1,300	5,620	30,412
Nuclear Radiation Division				
Government	7,113	4,930	6,880	16,029
Private Sector	10,957	14,107	13,350	37,302
Total	18,070	19,037	20,230	53,331
Radiation Physics Division				
Government	30,140	24,187	23,833	34,665
Private Sector	62,686	89,052	105,423	121,955
Total	92,826	113,239	129,256	156,620
Radiometric Physics				
Government	27,969	18,087	12,161	29,025
Private Sector	87,711	101,088	127,164	134,901
Total	115,680	119,175	137,195	163,926
Electrosystems Division				
Government	2,879	1,590	2,245	4,983
Private Sector	65,978	59,334	96,613	97,497
Total	68,857	60,924	98,858	102,480
Electromagnetic Fields Division				
Government	15,240	32,865	15,175	25,919
Private Sector	67,260	197,522	117,988	68,432
Total	82,500	230,387	133,163	94,351
Electromagnetic Technology Division				
Government	162,259	156,044	126,400	218,397
Private Sector	162,652	163,819	220,439	240,781
Total	324,911	319,863	346,839	459,178
Mechanical Production Metrology Division*				
Government	-----	10,165	28,637	66,992
Private Sector	-----	105,957	250,519	346,580
Total	-----	116,122	279,156	413,572
Automated Production Technology*				
Government	-----	25,450	36,761	20,740
Private Sector	-----	90,451	309,337	524,867
Total	-----	115,901	346,098	545,607

	FY 79	FY 80	FY 81	FY82
Industrial Systems Division*				
Government	-----	3,630	16,790	-----
Private Sector	-----	22,497	70,543	-----
Total	-----	26,127	87,333	-----
Fluid Engineering Division*				
Government	-----	19,145	19,497	52,618
Private Sector	-----	49,973	157,813	119,889
Total	-----	69,118	177,310	172,507
Thermal Processes Division*				
Government	-----	14,645	20,285	16,600
Private Sector	-----	1,420	30,806	30,622
Total	-----	16,065	31,091	47,222
Thermophysical Properties Division				
Government	-----	-----	-----	-----
Private Sector	-----	-----	-----	5,742
Total	-----	-----	-----	5,742
National Measurement Laboratory				
Government	170,588	116,577	128,041	188,920
Private Sector	714,332	750,792	862,241	1,015,603
Total	884,920	867,369	990,282	1,204,523
National Engineering Laboratory				
Government	312,330	369,931	265,790	422,353
Private Sector	909,249	1,078,449	1,254,058	1,491,506
Total	1,221,579	1,448,380	1,519,848	1,913,859
TOTAL - WASHINGTON				
Government	305,419	297,599	252,256	356,973
Private Sector	1,393,549	1,465,730	1,775,872	2,177,922
Total	1,698,968	1,763,329	2,028,128	2,534,895
TOTAL - BOULDER				
Government	177,499	188,909	141,575	254,348
Private Sector	231,412	363,511	340,427	329,139
Total	408,911	552,420	482,002	583,487

*These division totals are not for the entire fiscal year 1980 due to the reorganization of CMEPT in June 1980.

	FY 79	FY 80	FY 81	FY 82
TOTAL - NBS				
Government	482,918	486,508	393,831	611,321
Private Sector	1,624,961	1,829,241	2,116,299	2,507,061
Total	2,107,879	2,315,749	2,510,130	3,118,382

2.2 Measurement Services for Foreign Entities

The NBS Organic Act was amended in 1972. One of the provisions of the amendment, Public Law No. 92-317, authorizes NBS to perform services for Government agencies, organizations, and individuals of friendly foreign countries. Although the law is broadly written, it does require that NBS consult with other Government agencies and "in particular the Department of State with respect to foreign entities."

NBS did not have a formal policy or procedure for handling such requests until 1980. In that year the Office of International Relations (OIR) and OMS proposed an NBS policy and a set of procedures to implement the policy. These were adopted in January 1980. After about one year of implementation it was clear that the procedures were too cumbersome since they required extensive communications between OMS and OIR over routine matters. In October 1981 OIR and OMS agreed to transfer to OMS responsibility for approving routine requests for calibrations from foreign entities. These changes were reflected in a revised set of procedures which were adopted on April 26, 1982.

2.3 Management Information System

Extensive improvements have been made in the calibration management information system. In the past the data base was maintained on punched cards. Monthly reports were prepared using these cards as data input for the computer software which manipulated the data and prepared the reports using the NBS Univac 1108 computer.

The new system stores the data in mass storage (older data are stored on magnetic tape), data are entered from a remote terminal and all files are manipulated and edited from a remote terminal. New data are entered into the system as soon as they are available. The new system is online and interactive. This makes it possible for OMS to answer management requests almost instantly. Numerous new computer software modules have been written as a result of special requests for information.

All the previously used computer software modules have been recompiled using the latest version of Fortran on the new Univac 1100/82 computer system. Significant improvements have also been made in the format, style and content of the reports.

3. MEASUREMENT ASSURANCE PROGRAM DEVELOPMENT

During FY 82 OMS supported MAP development in five technical divisions: Electrical Measurements and Standards (521); Temperature and Pressure Measurements and Standards (522); Radiation Physics (533); Radiometric Physics (534); and Electromagnetic Technology (724). In addition, OMS supported three statisticians in the Statistical Engineering Division (714) who supplied technical consulting for MAP development and maintainance of MAP services. The reports of these divisions for FY 82 follow.

3.1 Electrical Measurements and Standards

MAP services in electrical measurements are utilized by the defense, aerospace, electrical instrumentation, and independent calibration lab community. Companies such as Rockwell, TRW, Beckman Instruments, Lockheed Electronics, and others are working closely with NBS to implement these programs.

Such companies employ MAP services to ensure the accuracy of their electrical measurements associated with new product development and production quality control.*

3.1.1 Reverse Regional MAP

Phase One of the pilot Reverse Regional Resistance MAP was completed in February 1982. A reverse MAP is one that operates using a customer owned standard (or set of standards) which is periodically calibrated at NBS and where the participants perform most or all of the data reduction in the long term. A group of transport standards was initially calibrated at NBS in the summer of 1981 prior to being sent to participants in the Los Angeles area. After initial measurements at a receiving laboratory to ensure a good transfer, the individual resistors were distributed and rotated through the group for calibrations according to a pattern designed to give a redundant intercomparison of the units as maintained by each of the laboratories. This group of standards is intended to circulate in perpetuity continuing the pattern to ensure good agreement among the laboratories. The data were analyzed and preliminary reports giving values of Ohm (Lab) - Ohm (NBS) for each participant were issued. The results were preliminary in the sense that no "after" NBS measurements were made to verify that the standards had not changed during transit. In fact, some did and replacements were made by the laboratories after intensive intercomparison with those NBS-calibrated standards believed good. The results indicated that laboratories of the "core" group (i.e., those with sub-ppm accuracy requirements) were maintaining units differing from the

---

*Control of critical measurements by MAP techniques allows companies to detect problems early and reduce their impact on product quality.

legal unit by much less than a ppm. The units of the two "satellite" laboratories were further away, but within seven ppm at the one-ohm level and one ppm at the ten-thousand-ohm level.

The Phase Two laboratory work of the experiment was completed and data analysis begun. During Phase Two, NBS transport standards at the one-ohm and ten-thousand-ohm nominal values were calibrated by each of the "core" group of four laboratories, as well as compared with the circulating standards from Phase One in order to provide closure to the initial results and to provide Phase Two traceability to the two satellite laboratories. The data analysis is expected to be complete in October.

3.1.2 New Regional Voltage MAP Group

A regional voltage MAP group in the NJ-NYC area was formed and the initial intercomparison experiment completed. A number of problems in the measuring systems in the participating laboratories were uncovered and most solved. After a recent meeting it was decided to do a transfer from NBS during September 1982.

3.1.3 New Capacitance MAP Transport Standard

A set of multi-layer ceramic chip capacitors supplied by a consultant have undergone a preliminary determination of suitability for use as a transport standard. The advantage of these capacitors is their size -- they are about 1/32 of a cubic inch in volume. Their disadvantage is that they have considerable dielectric hysteresis and must be kept under power when not in use. Further studies of their properties are needed before a prototype transport standard based on them will be designed.

3.1.4 Special MAP Service

OMS arranged for a special MAP service to be provided to an Army program (at Redstone Arsenal, Alabama) for the evaluation of automated meter calibrators. The experiment, designed by W. G. Eicke and performed by him and T. Leedy (CEEE), provided a measurement of the Army Calibration System's ability to supply standards and calibration support to a project under field conditions at test equipment accuracy levels. This is the first time that NBS has applied MAP techniques to a field-level measurement situation. Two transfers were undertaken using standard cells, resistors, a digital voltmeter, and a multi-range thermal-transfer meter as transport standards. Each transfer was individually reported in detail at the 1982 Annual NCSL Conference and will be described in a NBS Technical Note.

Publications:

1. Levy, C.R., Testing to Quantify the Effects of Handling of Gas Dielectric Standard Capacitors. Nat. Bur. Stand. (U.S.) Tech Note 1161; 1982.

2. Free, G., and Morrow, J., Transportable 1000 pF Capacitance Standard. Nat. Bur. Stand. (U.S.) Tech Note 1162; 1982.

3.2 Temperature and Pressure Measurements and Standards

Accomplishments for Fiscal Year 1982 for the Temperature MAP development fall into the two categories -- thermometry in the range covered by the new Provisional 0.5 K to 30 K Temperature Scale (EPT-76), and that covered by the International Practical Temperature Scale (IPTS-68). High technology companies need MAP services in order to ensure that their temperature measurements are consistent with IPTS-68, for example, AVCO, Boeing Aerospace Co., Pratt and Whitney and Duke Power Company. The low temperature MAP under development, because the scale is still provisional, is of greatest interest to thermometer manufacturers, typically small companies such as Lake Shore Cryotronics, and to government laboratories engaged in research and development of specialized cryogenic systems. Progress in each area is indicated below.

3.2.1 EPT-76

Three suppliers of cryogenic thermometers and calibrations as well as representatives from U.S. aerospace industries and DoD laboratories have expressed a serious commitment to this program. As a first step in this program, Messrs. R. S. Kaeser and E. R. Pfeiffer have been working to establish an accurate version of EPT-76 at NBS and to automate the measurement process. Their accomplishments this year include:

- Compared EPT-76 with other cryogenic temperature scales (the NBS 2-20 K Acoustic Scale; the NPL-1975 Gas Thermometry Scale; the IPTS-68; and the SRM 767 Superconducting Fixed Point Device). The results indicate a high quality of consistency and form the basis for the EPT-76 scale maintained at the NBS. The results were published in the Proceedings of the Sixth International Conference on Temperature. (1)

- Continued to improve the automation of the measurements by incorporating an automatic ac resistance bridge for use with Pt and RhFe resistance thermometers. A low-current bridge for cryogenic use was evaluated by E. R. Pfeiffer and R. S. Kaeser. This bridge was used to measure capsule type PRT's as well as RhFe resistance thermometers. Not all the results have been evaluated, but the intercomparison of two RhFe thermometers from 0.5 K to 27 K with this bridge showed agreement within 0.15 mK. (1) To accommodate the use of PRT's to higher temperatures, R. D. Cutkosky designed a new ac resistance bridge with a range 0-100 ohm. The ultimate performance of his system is now limited by leakage currents internal to the PRT which became increasingly troublesome at higher temperatures. Guarding techniques to circumvent this problem have met with some success. (2)

o Evaluated a new sensor (PtCo alloy resistor).

3.2.2 IPTS-68

This part of the MAP activity is more mature and consists of (1) assessing the accuracy of laboratory scales by exchange of SPRT's and (2) establishing a calibration scheme of lower accuracy and lower cost for industrial applications via "industrial" PRT's. G. T. Furukawa and W. R. Bigge have accomplished the following:

o Begun a document which will establish the procedures by which a laboratory may best employ the MAP concept to maintain their temperature scale.

o Participated with the ASTM E-20.03 committee in the preparation of a standard for industrial PRT hardware.

o Assessed the results of a round robin exchange of industrial PRT's.

3.2.3 Special MAP Seminar

The NBS staff hosted a one-day MAP Conference on March 19, 1982. Over 70 attendees from U.S. military and industrial standards laboratories were briefed on the NBS temperature MAP program by L. J. Kieffer, G. T. Furukawa, and E. R. Pfeiffer. Tours of the EPT-76 and IPTS-68 laboratories were also given. In responding to a questionnaire, attendees provided useful information on the benefits which participants could obtain from this program.

Publications:

1. Pfeiffer, E. R. and Kaeser, R. S. Realization of the 1976 Provisional 0.5 K and 30 K Temperature Scale at the National Bureau of Standards, Temperature, Its Measurement and Control in Science and Industry, Vol. 5. American Institute of Physics, New York; 1982. pp. 159-167.

2. Cutkosky, R. D. Automated resistance thermometer bridges for new and special applications, Temperature, Its Measurement and Control in Science and Industry, Vol. 5. American Institute of Physics, New York; 1982. pp. 711-713.

3.3 Radiation Physics

Present efforts have the primary objective of developing MAP services for laboratories that operate at the intermediate level between NBS and the field (user) level. The radiation of interest is photons (X and gamma rays) with energies ranging from 30 keV to 1.25 MeV. Essential tasks are development and/or adaption of instruments to be used as transport standards,

development and documentation of technical and administrative procedures, development of quality control and data analysis techniques, and implementation of routine MAP services.

3.3.1 General Procedures

During the past year, the principal and general procedures of a measurement quality assurance (MQA) program* for dosimetry calibration laboratories were developed and documented. The essential elements of the program are: (1) agreement between NBS and the calibration laboratory on the radiation qualities, dose rates, and measurement error limits to be considered acceptable; (2) calibration by NBS of the laboratory's in-house standard; (3) constancy checks by the laboratory on its standard; (4) periodic NBS measurement-assurance services (performance evaluations); and (5) recalibration of the laboratory's standard only when a need is demonstrated by the constancy checks or performance evaluations. Those principles and procedures were developed in cooperation with representative dosimetry calibration laboratories.

A questionnaire has been developed that will routinely be sent to laboratories that wish to participate in the MQA program described above. It will be used to establish the detailed technical characteristics of the interaction between NBS and each laboratory.

Contacts were made with additional calibration laboratories to explain the MQA program and determine their interest in participation. The program has generally been accepted with enthusiasm and, as a result, a total of 11 laboratories have indicated a desire to participate. They consist of national laboratories, instrument manufacturers, government agencies, and medical facilities.

3.3.2 Services Provided in FY 82

In FY 1982, measurement quality assurance services were provided to the three Accredited Dosimetry Calibration Laboratories (ADCL) of the American Association of Physicists in Medicine (AAPM). The ADCL formerly operated by Victoreen was closed in June, and was replaced several months later by K&S Associates in Nashville, Tennessee. Technical assistance was provided to K&S Associates by NBS in preparation for accreditation by the AAPM, including an MQA service in the form of a performance evaluation.

An improved method of conducting performance evaluations has been developed and applied. Two transport standard instruments are circulated to participating laboratories, and their response

---

*The ionizing radiation community, for historical reasons, uses the term MQA program to refer to what is generally called a "MAP" elsewhere.

ratio is provided. This ratio is then checked by the participant to determine whether the instruments' response has been affected elsewhere by transport and handling. If the ratio remains unchanged, the evaluation may proceed and the instruments may be sent to the next participant without intermediate return to NBS.

A cooperative effort to prepare a constancy-check protocol for intermediate calibration laboratories was begun with AAPM Task Group 3. This is the first attempt at preparation of such a recommended procedure, and will serve as a model for similar efforts in other areas of interest.

3.4 Radiometric Physics

The two pilot MAP services under development are for diffuse reflectance and retroreflectance. Diffuse reflectance services are needed by testing laboratories such as Sardner/Neotec and Hunter Asociate Labs who provide services to commercial companies who need to make mesurements of color and appearance. The retroreflectance services are needed by companies such as 3M Co., a manufacturer and EG&G, a measuring instrument maker.

3.4.1 Improvement and Development of MAP Facilities

The high accuracy transmittance spectrophotometer has been automated. The facility now includes a Cromemco microcomputer and interface system, including stepping motor control module, relay boards and I/O boards. The conversion also involved significant software changes.

The retroreflectance and diffuse-reflectance instruments now use Cromemco microcomputers and MIDAS interface systems. All software has been converted for these microcomputers.

The construction of new source and detector systems for retroreflectance chromaticity measurements is nearly complete. The source system includes a lamp housing, a high wattage lamp aperture and a lens system. The detector system includes an aperture-averaging sphere, a compact monochromator, a detector and a mounting plate. Because of a modification of the overall program, these two systems will be on hold for the time being.

3.4.2 Measurements and New MAP Transport Package Development

3.4.2.1 Retroreflectance CIL MAP.

The data of the measurements using a "1/3 factorial"* design have been analyzed for the effect of changing angles of incidence, observation and rotation on the CIL of cube-corner prismatic retroreflectors. The statistically significant

---

*Natrella, M. G. Experimental Statistics, Handbook 91, Chapter 12, U.S. Department of Commerce, issued August 1, 1963.

coefficients have been determined. Using these coefficients, overall uncertainties have been calculated based on estimated angular uncertainties.

Check standards of beaded sheeting and prismatic retroflectors have been measured to establish internal MAP procedures.

Four sets of color filters for checking spectral accuracy, have been polished and are ready for future use.

Two complete CIL MAP transport packages have been sent to, and were returned by, two laboratories - one instrument and one material manufacturer. These were pilot runs to test instructions, measurement procedures, data reporting and shipping. Data are being analyzed for spectral and angular uncertainties.

3.4.2.2 Diffuse Reflectance MAP

Four sets of neutral-density filters for checking instrument linearity have been polished. A total of five sets have been calibrated on the high accuracy transmittance spectrophotometer - three large-size sets, one medium-size set and one cuvette-size set. The large-size sets have been remeasured and the results indicate a very small change.

The diffuse-reflectance standards have been recalibrated. The diffuse-reflectance MAP transport package consists of one set of neutral-density filters, one set of 45/0 and one set of 6^{o}/hemispherical diffuse reflectors. Two complete diffuse-reflectance packages were sent to two instrument manufacturer laboratories for measurements.

3.4.3 Coordination With Users and Committee Activities

Staff members attended the 1982 Meeting of the Council for Optical Radiation Measurements, the AIC Color 81 Conference and the CIE Symposium.

The Group Leader for Spectrophotometry, J. Hsia, was appointed International Chairman of the CIE Subcommittee on Standards and Technique. Staff members participated in several committee and technical meetings on diffuse reflectance, retroreflectance and fluorescence, including: ASTM D-01.26 on Optical Properties, E-12 on Appearance, E-13.01 on UV and Visible Spectroscopy; ISCC Project 18 on Fluorescence and Project 22 on Materials for Instrument Calibration; CIE TC-2.3 on Materials Characterization and TC-1.3 on Colorimetry.

The absolute diffuse-reflectance factor, fluorescence, retroreflectance and spectrophotometric facilities at PTB and BAM, Germany, and NPL, Great Britain, were visited.

J. Hsia delivered a talk on "International Intercomparison of Absolute Reflectance Factors" at the 1982 Annual Meeting of the Council for Optical Radiation Measurements.

K. Eckerle consulted with ASTM Committee E-12 on statistical analysis and precision statement for retroreflectance measurements. He also consulted with the Rensselaer Polytechnical Institute on spectral transmittance measurements of liquid filters.

Publications:

1. Hsia, J. J. and Weidner, V. R. NBS 45°/Normal Reflectometer for Absolute Reflectance Factors. Metrologia 17: 97; 1981.

2. Budde, W., Erb, W., and Hsia, J. J. International Intercomparison of Absolute Reflectance Scales. Color Research and Application 7: 24; 1982.

3. Eckerle, K. L. and Hsai, J. J. Proposed Standards for NBS Retroreflection MAP. Color Research and Applications 7: 235; 1982.

4. Eckerle, K. L., Hsai, J. J. and Liggett, W. S. Prismatic Retroreflector for MAP Package, to be submitted to the Journal of Color Research and Application.

5. Eckerle, K. L., Weidner, V. R., Hsai, J. J. and Kafadar, K. Measurement Assurance Program Transmittance Standards for Spectrophotometer Linearity Testing: Preparation and Calibration, to be submitted to the NBS Journal of Research.

3.5 Electromagnetic Technology

3.5.1 Pilot RMAP for Microwave Power

Following the visits by NBS personnel to the five participating laboratories in the West Coast Pilot RMAP, a set of measurement instructions to be used by them was drawn up. These instructions were sufficiently general so that they could be used by any of the laboratories in spite of the rather wide divergence in measurement methods and equipment (e.g., automated versus manual) among the laboratories. The participating laboratories are as follows:

Boeing Aerospace	Seattle, WA
Hewlett-Packard Co.	Palo Alto, CA
TRW Systems Division	Los Angeles (Redondo Beach), CA
Hughes Aircraft Co.	Los Angeles (Culver City), CA
Rockwell International	Los Angeles (Anaheim), CA

In the plan devised, each participant would receive two thermistor mounts (coax-type N) MAP standards on which measurements of effective efficiency and/or calibration factor would be made. This approach would result in considerable time saving over that of sending the same two mounts to each laboratory in rotation. Our measurements on the ten mounts indicated that their differences in reflection coefficient and efficiency are small.

The MAP bolometers were sent to the participants during December 1981, and it was expected that all measurements would be completed within six months. However, only two laboratories have submitted data to NBS for analysis. These are Hewlett-Packard and Rockwell International. It is known that Hughes and TRW are having problems with non-repeatability of their measurements due to electrical mismatch arising from a lack of reproducible mechanical alignment of connector components. We will continue to work with them to resolve the difficulty.

3.5.2 Initiation of New Pilot MAP

The first steps to initiate a Northeast RMAP in microwave power have been taken with the recent visit by Hudson and Judish to six industrial standards laboratories. These included:

Weinschel Engineering	Gaithersburg, MD
Comsat Laboratories	Clarksburg, MD
Westinghouse	Baltimore, MD
Lockheed Electronics	Plainfield, NJ
PRD Electronics	Syosset, NY
Grumman Aerospace	Plainview, NY

As with the West Coast participants, a wide range of measurement capability was found to exist. At least two of the laboratories definitely need help and all were eager to join the RMAP. Because of Weinschel's application for accreditation under the NVLAP, it was decided to do a one-on-one with them so as not to delay further the preliminary work needed to complete the application.

These laboratories are in the process of updating and automating their bolometer mount calibration systems using new competing equipment and techniques developed by Hewlett-Packard and by Weinschel Engineering. Thus, they are at least six months away from being ready to begin the RMAP measurements.

Another laboratory, the Applied Physics Laboratory of Johns Hopkins University (Baltimore) has asked for inclusion in the Northeast RMAP, and it is likely that they can be accommodated. Westinghouse Laboratory in Baltimore was not certain that they would be able to participate because of severe budget cuts.

3.6 Statistical Engineering

Three staff members from SED are assigned full time to consult on MAP or calibration problems. In addition, several other SED staff consult part time on these problems. Their accomplishments in FY 82 are listed below by the NBS Division they assisted.

3.6.1 Electrical Measurements and Standards (521)

Analyzed data from the comparative inductance measurements on a new bridge, and pointed out some problems with the new

system; also worked out a design for intercomparing standards of different magnitudes.

Consulted with F. Hermach and J. Hastings on measurement designs and data analysis for thermal AC/DC converters.

3.6.2 Temperature and Pressure Measurements and Standards (522)

Met with G. Furukawa, and E. Pfeiffer on platinum resistance thermometer MAP and low temperature scale (4-90K).

Helped J. Wise develop software for liquid-in-glass thermometry calibration.

Assisted C. Tilford in the calibration of a manometer used as a primary standard and reviewed the test report to Brandt Industries.

Consulted with B. Welch relating to proper estimates of coefficients used in pressure equation for the calibration of controlled clearance piston-gages.

3.6.3 Radiometric Physics (534)

Collaborated with Ken Eckerle of Radiometric Physics Division on MAP's for transmittance standards and retroreflectance measurements.

Publications resulting from this work are reported under the report for the Radiometric Physics Division, Section 3.4.

3.6.4 Electrosystems (722)

Prepared a section on "error analysis" for inclusion in documentation for watthour meters, and reviewed the document (as a member of the subcommittee).

3.6.5 Semiconductor Materials and Processes (725)

Collaborated with D. Nyyssonen and John Jerke on the documentation of linewidth SRM and interlaboratory test.

Collaborated with D. Nyyssonen on optimal design for line-width measurements on wafers, also design for interlaboratory test for same.

3.6.6 Mechanical Production Metrology (737)

Worked out weighing designs for a special set of weights from Brinkman to be calibrated by NBS.

General maintenance, updates, tape requests, etc. for mass MAP.

3.6.7 Automated Production Technology (738)

Completed analysis of MAP gage block data for Beckman, Ford, Duke, Power and Lockheed. Results given to John Beers.

Updated data on check standards used in long block calibration.

3.6.8 Other Consulting in Gaithersburg

Consulted with W. Eicke and T. Leedy on the measurement plan and data analysis for the Redstone Arsenal Special MAP, and contributed to the writing of the Report of Calibration.

Worked on the Calibration Workload Management System of OMS.

Discussed volume MAP for OWM with C. Brickenkamp and Henry Oppermann.

Worked on Part II of the MAP Handbook with five chapters.

3.6.9 MAP Consulting and Collaboration in Boulder

Collaborated with Neil Larson (724) on VOR Bearing Angle Calibration and provided a provisional statement of uncertainty for the service. A Technical Note is being reviewed by the Subcommittee.

Consulted with Glen Engen (724) on mathematical and statistical basis for the development of Dual six-port calibration service. Difficulty involves "ad hoc" versus "accepted" mathematical and statistical methods.

Consulted with D. Wait (723) on the development of total power radiometer calibration service.

Publications:

1. Varner, R. N., Computer Software for Measurement Assurance of Gage Blocks. Nat. Bur. Stand. (U.S.) Tech. Note 1168; October 1982.

2. Croarkin, M. C. and Varner, R. N., Measurement Assurance for Dimensional Measurements on Integrated-Circuit Photomasks. Nat. Bur. Stand. (U.S.) Tech. Note 1164; August 1982.

3. Croarkin, M. C. and Varner, R. N.Interlaboratory Study of Linewidth Measurements on Anti-Reflection Chromium Photo Masks. Nat. Bur. Stand. (U.S.) Spec. Publ. 400-74.

4. CALIBRATION ADVISORY GROUP

4.1 Introduction

The Calibration Advisory Group (CAG) was established by the NBS Director to provide broad oversight for Office of Measurement Services (OMS) calibration-related activities and advise the MOU Directors on matters concerning the technical quality and the management of the calibration program. OMS provides the Secretariat for the CAG.

4.2 Guidelines

The CAG met eight times in FY 82. The major activities, in addition to the annual report which is discussed below, were development of guidelines to assist the technical divisions in implementing the new policies on quality control for advertised calibration and MAP services. The first six guidelines:

1. Long Range Planning for Calibration and MAP Services
2. Sample Format - Report of Calibration or MAP
3. Sample Format - Report of Special Test
4. Indicators for Calibration or MAP Problem Areas
5. Quality Assurance for Calibration or MAP Services
6. Documentation for Calibration and MAP Services and Special Tests

were approved and circulated by the National Measurement Laboratory and the National Engineering Laboratory.

4.3 Notification to Calibration Customers

During the spring review (1982) of the calibration services, the Director of NBS questioned whether the customers were being kept informed about the status of their requests. He suggested there should be a uniform system for informing the customers when their standards and purchase orders arrive at NBS.

The CAG reviewed the procedures of the various divisions. While at first one might think that a single form for everyone to use (e.g., the customer copy of the NBS 64) would be sufficient, it was clear from the discussions that this is not realistic. MAP services require a different type of communication than calibration services. In many cases we require additional information from the customer if the purchase order does not clearly state the service being requested or lacks some other important information. In other cases services must be prearranged, hence the customers need to be informed when it is time to ship their standard to NBS. There are many other situations requiring different communications with customers. Because of this, CAG

has proposed a set of guidelines. The guidelines include a detailed discussion of all the required elements of a customer notification system.

4.4 Measurement Seminars

The Electrosystems Division announced a seminar on "Metrology of Modern Electronic Instrumentation" in the October 1981 SP 250 Appendix. Prior to publication of this announcement, Electrosystems Division staff contacted a number of metrologists in industry and government laboratories and concluded that because of budget constraints it appeared that not enough people would attend to recover the costs. Therefore they decided to cancel the seminar. Unfortunately the announcement had already been printed and circulated. This issue was raised at the January Board Meeting of the National Conference of Standards Laboratories (NCSL), and later brought to the attention of the CAG. The CAG has issued a guideline spelling out procedures for announcing seminars designed to ensure adequate communication with potential seminar attendees.

4.5 CAG FY 81 Report

The CAG issued its first annual report: "The Status of NBS Calibration Services 1981." Many issues were raised, some of which will be described below. A brief status report on activities related to these issues is given.

Issues

A. Turnaround Time

The major complaint from calibration customers is the long time between sending their standards to NBS for calibration and receiving them back. In most cases excessive turnaround times are attributable to a shortage of trained staff. Several divisions have found that batching and scheduling increases efficiency and greatly reduces the problem. Significant improvements have been made by using these techniques. For example, in services provided by the Electrical Measurements and Standards Division, the average "turnaround" time for calibration of saturated cells was reduced from 60 days to about 36 days and for decade resistance from 48 days to 16 days.

B. Documentation

NBS policy now requires that all new services classified as Calibration or Measurement Assurance Program Services must be reviewed and approved for adequacy of documentation and quality assurance before being offered to the public via listing in SP 250. Currently listed services have until 1986 to meet these requirements. The NBS Divisions providing calibration services have provided plans to the CAG for meeting these deadlines. These plans are updated yearly and reviewed by the CAG and summarized in their annual report.

C. Special Issues

Several specific services listed in SP 250 were identified as candidates for phase-out or de-listing. These items are discussed below including their current status.

SP 250 #	Title	Comments
1.2	OWM Prototype Testing	These services are not calibrations and listing in SP 250 was removed in the April 1982 Edition of the Appendix.
1.9A	Refractive Index	These services were seldom used and no permanent staff were assigned. A survey of previous customers revealed that these services could be obtained from private labs. With the approval of CAG these services were removed from the April 1982 SP 250 Appendix.
2.4	Structural Engineering Measurements	The CAG reviewed these services and concluded they should not be classified as services in the SP 250. They were removed from the April 1982 SP 250 Appendix.
2.9D	Dynamic Response of Mechanical Rotary Anemometers	No requests for these services have been received for some years. Because of this the Center for Chemical Engineering plans to request approval to withdraw these services. No formal request has been received as yet.

7.8B-E	Spectral Transmittance Standards	The Radiometric Physics Division (534) has reviewed these services and concluded that the best long term solution is to transfer the routine calibration of these standards to a private laboratory which would be accredited by the Council for Optical Radiation Measurements (CORM). NBS would ensure the integrity of the system by ocasionally providing special services to the intermediate laboratory as part of the accreditation process.
8.2P,Q,R	Beta-Particle Solution Tests	This service is seldom used and the Center for Radiation Research has begun the process of phase out. A notice has been published in the April 1982 and subsequent issues of the SP 250 Appendix announcing termination of these services in December 1983.

D. Status of Calibration Services

As part of the CAG review process each of the CAG members were assigned specific calibration services to review. Every service listed in SP 250 was reviewed. All reviews were conducted by personal interview. The information gathered was summarized in a table (Appendix B in the report). The specific purpose of this review was to uncover and call to management's attention problem areas. The specific areas of concern were turnaround time, equipment, personnel and R&D backup. If any of these areas was identified as a concern for a specific service, comments and recommendations were made.

5. OTHER OMS ACTIVITIES

5.1 Talks and Conference Presentations

Belanger 38th Annual ASQC Quality Control Conference, Rochester, New York, March 9, 1982, "Traceability to NBS--Is A New Approach Needed?" (Invited paper).

Measurement Science Conference, San Diego, Calif., January 22, 1982, Session Developer--"NBS/DoD Cooperation in Measurement Science R&D".

Measurement Science Fair, Butler County Community College, Butler, Pennsylvania, April 1-2, 1982; lectures on "Metrology at the National Bureau of Standards."

Kieffer — Conference on the NBS Temperature Measurement Assurance Program, NBS, March 19, 1982, "NBS Measurement Assurance Program."

5.2 Publications (also see MAP sections)

NBS Special Publication 250 - Calibration and Related Measurement Services of the National Bureau of Standards, 1982 Edition, L. J. Kieffer, Editor.

5.3 Seminars Sponsored

Belecki, N. B. — Measurement Assurance Seminar, NBS, May 27, 1982, "Reverse Resistance MAP Experiment."

Oppermann, H. O. — Measurement Assurance Seminar, NBS, December 8, 1981, "Mass Measurement Control for State Laboratories."

5.4 Technical and Professional Committee Participation

OMS's involvement in the voluntary standards community continued at a high level in FY 82, with emphasis on incorporating measurement assurance concepts into voluntary standards. B. Belanger continues to be active in ASTM Committee E-46 (Quality Provisions in ASTM Standards). In 1981 the committee approved Belanger's proposal to restructure the creation of a quality systems manual, and the committee began work on a series of guideline documents on various aspects of quality assurance. Belanger heads Task Group E46.10.03 which has produced a document entitled, "Standard Guide for the Treatment of Calibration and Measurement Accuracy in ASTM Standards". This document, the most comprehensive of those produced to date by E-46, has been combined with four other shorter guideline documents into an overall guideline that is now being balloted by E-46.10.

Belanger also chaired a task group of the Writing Group for Quality Standards for Calibration Systems and Measurements of the ASQC/ANSI Z-1 Committee on Quality Assurance. The tutorial material on measurement assurance methods, drafted by Belanger and reviewed by other NBS staff, e.g., the Statistical Engineering Division, has been incorporated into the standard, which is now at the Intermediate Approval Level.

OMS participated in the NBS/Montgomery County Public Schools Science and Technology Enrichment Program. Lecture demonstrations were presented by Belanger at several schools in the county, and he participated in a career day during which opportunities for women and minorities in the field of measurement science were stressed.

Assistance was provided to Butler County Community College, Butler, Pennsylvania in develcping their metrology curriculum. Belanger lectured at the Butler Measurement Science Fair on NBS' activities in measurements and standards and encouraged women to pursue metrology careers. A tour of NBS for students and faculty was arranged in September of 1981 and again this year. In Butler's first metrology class last year, there were no women enrolled in the program. This year's class includes over 20% female students!

OMS has worked to strengthen ties with the Department of Defense during FY 82. Special measurement assurance services were arranged in response to a request frm Redstone Arsenal. OMS also coordinated the NBS response to a special request for technical assistance from Fort Belvoir. A meeting was arranged between the Calibration Coordination Group and the NBS Director's Office to plan a joint strategy for ensuring adequate funding for measurement research and development of interest to DoD.

OMS continues to be active in NCSL. Kieffer has worked with the National Measurement Requirements Committee during the past year and prepared several news items for the newsletter. Belanger attended four regional meetings and several Director's meetings, and served as Conference Co-Chairman for the 1982 Conference in Gaithersburg. He is now the OIML Liaison on the NCSL Board.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 82-2592	2. Performing Organ. Report No.	3. Publication Date December 1982

4. TITLE AND SUBTITLE

Annual Report - Office of Measurement Services

Subtitle: Programmatic Activities

5. AUTHOR(S)

Lee J. Kieffer

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This publication describes the programmatic activities of the Directorate for Measurement Services in Fiscal Year 1982.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Calibration; measurement; measurement assurance; measurement service; regional measurement assurance.

13. AVAILABILITY

☐ Unlimited

☒ For Official Distribution. Do Not Release to NTIS

☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

15. Price